were submerged. The inundated district in St. Louis was confined to Front street and to railroad tracks on low ground in the northern portion of the city. A few railroad embankments gave way in East St. Louis, and small areas were flooded. The loss in the two cities was, therefore, nominal, and resulted mostly from the suspension of business in the overflowed districts. The loss of, and damage to, property for the entire district was about $500,000, and the value of the crops destroyed was about $4,000,000. Damage to farm lands by erosion and deposit amounted to about $100,000. The loss sustained thru the suspension of business amounted to about $200,000. Timely warnings, issued in advance of this flood, gave ample opportunity for the removal of all portable property and live stock from the threatened districts to places of safety, and it is estimated that property to the value of $750,000 was saved by heeding them. There was no loss of life due directly to the flood, so far as press reports show. Between Louisiana, Mo., and the mouth of the Missouri River the stages were not alarming.

More moderate floods occurred in the Mississippi River from Chester to Cairo, Ill., for which warnings were issued as occasion required. While these warnings were frequent and accurate, much damage of an unavoidable character was done. The season was so late that the floods were much more destructive than usual, except in the vicinity of Chester, Ill., where the damage was small. Below Chester the losses and damage amounted to about $850,000, principally to growing crops. There were also local floods in small streams in various portions of the country during the month of July, due to heavy rainfall. Considerable damage was done in interior New York, northern and western Maryland, southern Virginia, southeastern Nebraska, Colorado, and southwestern Idaho.

The highest and lowest water, mean stage, and monthly range at 207 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

RAIN-MAKING IN NEW ZEALAND.

An article on experiments in rain-making in the New Zealand Times of Wellington, October 23, 1907, lately came to the attention of the Editor as another illustration of the waste of public money consequent upon popular ignorance and superstition. Of course it is not to be expected that every one should appreciate the positive knowledge that constitutes meteorology, but it is to be hoped that every illustration of this kind may contribute something to the education of the public.

We understand that both climatology and meteorology are combined in the Meteorological Office of New Zealand, but that of course the former branch of the science is likely to receive the greater amount of attention. It would seem that the people and the Government initiated the rain-making business at Oamaru in the North Otago district which had been suffering from a drought for several months; and it was only left for the Meteorological Office to send the Rev. D. C. Bates, F. R. M. S. and Government Meteorologist, to watch the experiments and report on the results. Of course he knew that the production of rain by cannonading is hopeless, and it would have been proper to regard the experiment as a stupendous farce. But it had a tragic aspect, since on the one hand he, on arriving at Oamaru, seems to have been hailed as a plenipotentiary armed with dynamite, guncotton, gunpowder, special railway trains, motors, and a posse of troops to do his bidding, in the presence of thousands of strangers. On the other hand, the local rain-making committee had caused the churches to offer up prayers for rain and for the success of the experiments, and now stood ready to denounce both religion and science if rain did not follow the cannonading. It seemed like a contest between paganism and intelligence in which forbearance, silence, and patience are the better weapons.

The official report by Mr. Bates has been published almost entire in the local papers of New Zealand and we reprint it as a most instructive scientific and educational document. The result should go far to prevent other communities from making such foolish experiments and should draw the attention of every one to the need of saving the rainwater after it has fallen. It is a case where conservation is possible and production impossible.—*C. A.*

REPORT UPON THE DRY PERIOD AND RAIN-MAKING EXPERIMENTS AT OAMARU, NEW ZEALAND.

By D. C. BATES, Government Meteorologist. Dated Wellington, N. Z., September, 1907.

The district of North Otago, often called after its chief town, the Oamaru district, is sheltered on the west, north, and south by mountainous ranges, which condense and precipitate on their windward slopes much of the moisture borne by the winds from these directions, and it must therefore depend chiefly on easterly weather [winds] for its rains. The northeasterly and southeasterly winds which accompany cyclonic disturbances and are usually laden with water-vapor, sweep up the Kakanui and Waitaki valleys, causing the most abundant rains to fall over the district. In some seasons, however, these atmospheric movements do not extend their influences so far south, and then, while the North Island gets more than the usual amount of rain, those parts of the South Island depending upon them are liable to experience droughts. A prolonged dry period of an unusually severe character for any part of New Zealand, extended over the Oamaru district during the years 1889, 1890, and 1891. The years 1897 and 1898 were also very dry, and the last period of deficient rainfall from January, 1906, to August, 1907, was 45.7 per cent below the sum of the average monthly rainfalls for the eighteen months included.

Rainfall observations for the Meteorological Office have been kept at Windsor Park, Oamaru, since 1892 by Messrs. E. and W. Menlove; also at Kauroo Hill, near Maheno, by Messrs. R. A. Chaffey, C. de V. Teschemaker, and A. French from January 1, 1890. While in Oamaru I learned that much older records, extending from 1866 to 1893, had been kept by the late T. W. Parker, esq., Resident Magistrate, and these were presented to the Meteorological Office by Mr. H. Edwards, who had continued Mr. Parker's work for a few years. Another valuable record, from 1888 to the present, with many interesting details of the effects of the weather upon pastoral and agricultural affairs, was also loaned us by Mr. Jas. Macpherson of Totara Station.

The annual rainfalls for Oamaru are as follows:

TABLE 1.—*Annual rainfall at Oamaru, New Zealand, 1867 to 1906.*

Year.	Inches.	Year.	Inches.	Year.	Inches.	Year.	Inches.
1867	23.58	1877	26.75	1887	26.28	1897	14.12
1868	25.73	1878	20.26	1888	29.10	1898	15.96
1869	18.33	1879	25.26	1889	14.33	1899	27.41
1870	32.82	1880	20.37	1890	14.15	1900	20.36
1871	16.32	1881	13.47	1891	16.60	1901	18.79
1872	19.93	1882	25.67	1892	23.03	1902	29.56
1873	28.00	1883	28.23	1893	20.04	1903	18.37
1874	21.79	1884	26.82	1894	23.71	1904	19.62
1875	23.39	1885	16.81	1895	24.26	1905	23.26
1876	17.20	1886	26.36	1896	23.75	1906	14.81

The average rainfall for these forty years is 21.87 inches;

the maximum of 32.82 inches occurred in 1870, and the minimum, 13.47 inches, in 1881.

TABLE 2.—*Precipitation data for Oamaru (Windsor Park), New Zealand.*

Months.	Means, 1867 to 1906.		During the drought.			
	Rainfall.	Days with rain .01 or more.	Rainfall.		Days with rain.	
			1906.	1907.	1906.	1907.
	Inches.		*Inches.*	*Inches.*		
January	2.24	12	....	0.43	....	5
February	1.88	11.6	1.25	1.39	13	9
March	1.82	9.7	0.52	1.41	10	11
April	1.73	9	1.16	0.58	5	7
May	1.62	8	0.73	0.71	4	2
June	1.78	7.4	1.42	0.24	5	4
July	1.67	8	0.59	0.56	6	7
August	1.47	8	0.59	....	4	....
September	1.89	9	1.46	....	8	....
October	1.55	10	0.62	....	7	....
November	1.98	11	0.95	....	5	....
December	2.30	13	2.46	....	10	....
Year	21.43	116.7	....	....	....	....

These figures indicate that the expectancy of rain is greater in summer than in winter. Furthermore, at Windsor Park during 1906 and 1907 only one month (December, 1906) had a total rainfall above the average, and that by merely 0.16 inch.

As might be expected in that undulating country, the records from Kauroo Hill station differ from the above very considerably at times. The averages from the seventeen years' records at Kauroo Hill, and the quantities during the eighteen months' dry period, January, 1906, to July, 1907, are given in Table 3.

TABLE 3.—*Precipitation data for Kauroo Hill, New Zealand.*

Months.	Means, 1890 to 1906.		Rainfall during drought.	
	Rainfall.	Days with rain.*	1906.	1907.
	Inches.		*Inches.*	*Inches.*
January	2.61	9.8	....	0.46
February	2.19	7.8	1.42	1.95
March	1.68	6.6	0.49	1.63
April	1.24	6.8	0.99	0.78
May	0.94	4.5	0.71	0.80
June	1.18	4.4	1.19	0.23
July	1.28	5.0	0.48	0.50
August	0.69	4.6	0.50	....
September	1.97	8.2	2.29	....
October	1.42	8.0	0.45	....
November	2.08	9.4	0.98	....
December	2.31	10.9	....	....
Year	19.59	85.5	....	....

* Number of days with .005 inch or over.

The total at Kauroo Hill for this period is thus found to be 39.1 per cent below the average.

The results of this small rainfall, though by no means comparable with the effects of droughts I have experienced in the heat of Australia, were more severe than I had imagined possible in this country. The fields were very bare, especially new pastures which had been sown with English grasses in the past few years. The fields which were being plowed showed a dry subsoil which had apparently not been moistened by a good rain for a long time. I drove over a great part of the district and saw only one small field of fair-sized turnips, while on an average between 50 and 60 truck loads of these roots were being brought from Southland every day for northern and central Otago. The stacks of straw which the farmers have at last learned to save at harvest time, were commanding high prices, and in addition quite 9,300 tons of fodder had to be imported by the settlers to keep their starving stock alive. This food was carried free for the purchasers from the south, who were thus relieved of a great stress and encouraged to save their stock. Much of the stock had to be removed elsewhere for pasture and sold off or killed, but nearly all left were in very poor condition, and I attribute the fact that very few dead are seen in the fields to the timely and generous assistance of the Government.

The acreage and yields for the Waitaki agricultural district for the past ten seasons, as published by the Agricultural Department, show a lower yield in wheat for 1906–7 than any year since 1897–98, while the yield per acre in oats was the lowest recorded.

TABLE 4.—*Acreages and yields in wheat and oats, Waitaki district.*

	Wheat.		Oats.	
	Acres.	Average yield per acre.	Acres.	Average yield per acre.
		Bushels.		*Bushels.*
1897–98	37,955	13.2	21,080	21.7
1898–99	44,423	36.6	19,268	43.3
1899–1900	29,936	36.4	21,216	48.2
1900–1901	22,347	31.4	24,696	48.6
1901–2	18,558	32	23,094	38
1902–3	21,594	39	27,075	55
1903–4	27,112	39	22,376	42
1904–5	28,808	40	18,567	47
1905–6	27,927	32	20,655	41
1906–7	24,925	20	19,688	20

To sum up this aspect of affairs I would like to quote a concise statement by the Oamaru correspondent of the Wellington Evening Post (August 12, 1907), who says that—

The eighteen months' drought at Oamaru has cost the district not far short of a million sterling. On the last grain harvest, as compared with previous averages, there was a loss of £200,000, and loss on the decreased output of butter ran into nearly another £50,000. It has been computed that about 75 per cent of cattle and 50 per cent of sheep that were in the district twelve months ago have been potted or exported to more favored districts.

Under such trying circumstances it was tantalizing to the farmers to hear of good rains falling in other parts of the country, and to see the clouds at such times hang over the mountains or passing away, high up in the air, to the ocean. Such disappointment as they so frequently experienced led many inhabitants of the district to regard favorably the project of experimenting for the purpose of inducing the clouds, at some favorable opportunity, to yield their moisture. Several of the most progressive, enlightened, and experienced farmers and business people who have the best interests of the community at heart—men who support local affairs such as pastoral and agricultural shows, and who have introduced and experimented on new seeds and strains of stock in the district, promoted the experiments, arguing that it *might be possible*, for a small outlay, to secure results of infinite value. The promoters were men who commanded the respect and sympathy of the public, and a large sum of money was readily subscribed. This amount, thru the efforts of Mr. J. Macpherson, M. H. R., was also supplemented by the Government, and given its greatest power of purchase through the supply of explosives at cost price from the Defense Department of New Zealand. I was ordered to proceed to Oamaru simply to watch and report upon the proposed experiments.

On my arrival I was met by the members of the committee who had the matter in hand and, while disclaiming all responsibility for the experiments, I discussed the project freely with them, finding their idea was to seek favorable opportunities to cause the passing clouds to precipitate. They desired me especially to advise them as to these, and to indicate times when the air would be saturated with moisture, or (to adopt a phrase of the late meteorologist, Rev. Clement Ley) the existence of such a state of "unstable equilibrium" as might possibly be disturbed and the "water-dust" of the clouds be made to coalesce and precipitation ensue. They did not hold that they were able to produce rain at any time, but firmly believed that they could only operate successfully in a cloudy and saturated atmosphere.

Tho I could not share their very sanguine hopes for such results as they desired, yet I tried my best to meet their views, and to the utmost of my abilities cooperated heartily with the committee. I only wish that more of the committee could have witnessed the experiments and, with the press, also come to definite conclusions.

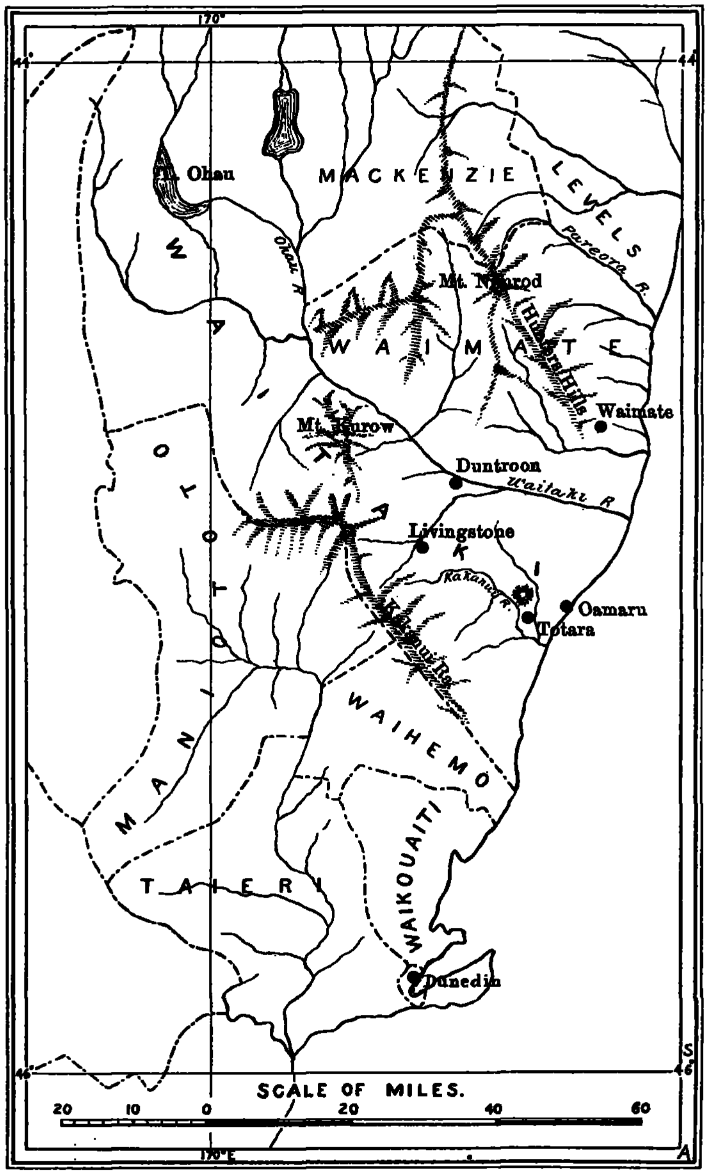

FIG. 1.—Sketch map of part of the North Otago district, South Island, New Zealand.

Rain was badly wanted, and at first the committee were too much in earnest, both in their faith and efforts, to regard the experiments in the light of purely scientific experiments. As is well known, rainfall is one of the most uncertain elements in meteorological prognostication for such a district, and the "probability of rain" with certain disturbances, rarely amounts to absolute certainty. But events were moving in such a manner that I could forecast periods of saturation in the near future [due to such meteorological causes as are ordinarily recognized on any weather map]. The times thought most favorable for rain, fortunately for the district, coincided very nearly with such widespread and abundant rainfalls as had not occurred for years, and on this account, my task of giving conclusive evidence as to cause and effect in the experiments was, unfortunately, rendered more difficult. While admitting this, I desire most clearly to maintain that in no case was I able to trace such effect or success in rain-making due to the explosions, as some local residents claimed with considerable assurance at the time. I have, moreover, read the records of similar experiments made on November 27, 1901, on Raki's Table which were referred to with even greater confidence. Rain did fall at that time, but I find from our records that the fall was heavy and general between Cape Campbell and Dunedin. The reports of the effects of the explosions on the clouds, barometer and hygrometer, are interesting but by no means of a convincing character. For example, one report states that "before the experiment the barometer stood at 28.95 inches, and five minutes after the explosion it fell to 28.92 inches, ten minutes afterward to 27.75 inches, and was apparently continuing downward when we left the Table." Now a fall of the barometer, in the open air, of at least one and one-fourth inches, would probably show a world's record for all time,[1] and one need hardly discuss the possible effects of such a drop. We might almost speak of it as a vacuum in the atmosphere. The chief claim for other experiments was based on this reported change. In every case where the committee and myself watched reliable barometers near the explosions, only a slight quiver was noticed at the moment of detonation, while the instruments went on steadily rising or falling as at other neighboring places.

The sites chosen for the experiments were lonely hills which commanded views of the whole district, and on that account had all been used as trigonometrical stations for the survey of the district. (See the map, fig. 1.) The chief site is Raki's Table, a flat-topped hill 1,059 feet above sea level and 14 miles inland as the crow flies, north-northwest from Oamaru. Round Hill, on the Totara Estate, is a remarkable cone with an elevation of 501 feet above mean sea level and about six miles southwest from Oamaru. Dalgety's Hill, near Duntroon, is in the Waitaki watershed, about 811 feet above mean sea level and 15 miles northwest from Oamaru. The positions had been carefully chosen by the committee, and both the situations and elevations were admirable for the purpose. The aim was to work with the wind rather than against it, and it was hoped that we should be able to trace the effects of the explosions on the clouds over the area affected.

THE FIRST SERIES OF EXPERIMENTS.

On the afternoon of August 16 the skies were dull; stratocumulus clouds hung round the hills and were scattered overhead. It appeared even to be raining at a distance away to the south, but the weather was quite fine for us on our way to Arnmore station, near Raki's Table. I arrived at Mr. P. I. Shand's residence about sunset, and although heavy, misty clouds were falling on the Table and residents thought rain imminent, there did not seem to be sufficient density about the clouds. The air showed a relative humidity of 92 per cent, and only needed a fall of 2.4° in the thermometer to reach the dew-point. The cool of evening was approaching and the wind, tho light, was in the rainy quarter, the southeast. On the whole, the conditions were regarded as fairly favorable. It was regarded chiefly as a trial of the bombs and for working the men together under Corporal Meikle prior to using the other stations.

The explosives used on this occasion were:

(1) 5:15 p. m... 17½ lbs. dynamite, 12½ lbs. powder, in keg.
(2) 5:30 p. m... 17½ lbs. dynamite, 12½ lbs. powder, in keg.
(3) 5:45 p. m... 40 lbs. dynamite, 25 lbs. powder, in case.

These behaved differently. The first shot gave off a good report, and the smoke rose and drifted gently away to the northwest. The second did not explode well, for the powder seemed to burn in the air without detonation. The third shot, which had a weight of 65 pounds, gave a great concussion to the air, and vibrations were felt over a wide area.

[1] It is a physical impossibility.—*C. A.*

As far as I could see, however, there were no other than natural changes going on in the atmosphere. With the committee I left for Oamura at 10 p. m., and the evening was quite fine. In the Oamura Mail, however, next day, the following paragraph appeared:

> As showing that the explosions which took place last evening, altho modest compared with what are to follow, were not altogether unaccompanied by that practical result which farmers look for as the outcome of the experiments, it may be mentioned that Mr. George White and several other farmers were conversing on the probability of rain descending from a certain cloud which appeared to be hanging on Tokaraki, if unsettled by concussion, at the time the bombs were, altho unknown to Mr. White and his friends, being tested on Raki's Table; and as they conversed they were surprised to hear the boom of the explosions, and immediately afterward a shower of rain, lasting for half an hour, fell in the vicinity of Hilderthorpe. This may have been a coincidence, but as a coincidence it is remarkable.

As a result of this trial it was decided that the explosions should be given more resistance, fired off rocks, and at the next opportunity detonated almost simultaneously from the other stations. A small cannon with a few pounds of common powder would, in my opinion, have given greater vibrations of sound and a shorter and sharper shock in place of the dull and heavy report of these powerful explosions. I believe that the cannons used in Europe for this purpose are of the blunderbuss type, but I would not advocate their purchase; for tho numbers of these have been employed together, and some sending "vortex rings" up to great heights have had great claims made for them by their vendors, yet they are by no means recommended by those meteorological experts who have investigated their claims. They have been used mostly for the prevention of hail, to drive it away or to cause the cloud to precipitate as rain before the formation of hail. Theoretically one would imagine the heat caused by these explosions would tend to dissipate the clouds, the friction of the vortex rings especially would be able to create but slight disturbances in the air, which would not induce precipitation, but naturally rather the reverse.

THE SECOND SERIES OF EXPERIMENTS.

On Sunday, August 18, the coming of what appeared to be merely a westerly area of low pressure developed into a cyclone, which promised greater rain and sooner than it would have come from the ordinary type which would have culminated between the 19th and 20th. There was a drizzle falling on Sunday morning at Oamaru at 4 a. m., and at 9 a. m. 0.04 inch was recorded. The day was dull and threatening and rain set in again at night; 0.40 inch was recorded in the morning. At Totara Station in the Kakanui Basin, Mr. Macpherson recorded 0.73 inch. The rain was mostly confined to the seacoast while the barometer was falling. It was 29.99 inches on Saturday, and 29.47 inches on Monday at 9 a. m. I expected much more rain would come with the rise of the barometer and the shift of the wind to the south, but as yet hardly any rain had fallen inland. The rain held off, but the skies continued cloudy. The committee decided to experiment at Raki's Table when they heard no rain had fallen there. We left Oamaru at 12:30 p. m. on the 19th, and as we got out into the country found the roads dry, but "bad" weather was evidently working inland and there was a very slight drizzle falling as we arrived at Armore about 1:45 p. m. Corporal Meikle was then making an explosion which apparently had no effect, tho the hygrometer showed that the air was saturated with moisture. Earlier, at 12:30 p. m., another shot had been fired, and the artillerymen and others affirmed that it drew rain in fifteen minutes, and brought the clouds down on the Table so that the view of the surrounding country was obscured. We missed the artillerymen on the road but in company with Mr. Shand, I at once visited the top of the Table. We found the wind strong and gusty from the southeast. The sky was dark and lowering and two showers fell before the artillerists returned. Raki's Table was then enveloped in a thick Scotch mist, spitting with rain, but heavy showers soon set in and continued to fall at intervals. I regarded these as perfectly natural, and was confirmed in my opinion when I learned that the rain squalls had had the same intermittent character long before they reached us. It could hardly be maintained that the explosions would have so marked an effect as this on the rain 14 miles away, and against the sweep of a wind averaging, at the Table, about 25 miles an hour. While I saw no perceptible difference made in the showers sweeping down upon us and moving over the country, others were quite as decided in their opinions that the rain thickened heavily after each successive shot.

The barometer continued to rise, and those who watched the instrument agreed there was no fall after the several shots. The weather continued very raw and wet, but the hygrometer showed the same dew-point as before.

The explosions were as follows:

Time.	Guncotton.	Dynamite.	Gunpowder.	Weight of charge.	How made up.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	
(4) 12:30 p. m.	....	50	....	50	In 5-gallon oil drum.
(5) 1:45 p. m.	....	....	50	50	Do.
(6) 3:56 p. m.	....	50	....	50	Do.
(7) 4:05 p. m.	....	65	....	65	In case.
(8) 4:17 p. m.	50	60	....	110	Do.
(9) 4:30 p. m.	50	100	....	150	Do.
	100	325	50	475	

Rain fell on the 19th and 20th over a very wide area in the South Island, and the falls recorded at this time by the observers of the Meteorological Office are as follows:

	Windsor Park.	Otekaike.	Livingstone.	Arnmore.	Kurow.	Waimate.	Oamaru.	Totara.	Kauroo Hill.
	Inches.	*Inches*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
18th...	.16	.00	.00	.03	.00	.00	.40	.73	.00
19th...	.53	1.15	.70	.52	1.17	.03	.36	.40	.10
20th...	.00	.15	.53	.09	.12	.50	.00	.06	.70

The falls were very different at the various places, but such widespread and heavy rains could hardly be attributed to artificial means.

THE THIRD SERIES OF EXPERIMENTS.

On the 22d everything was ready for a trial upon a larger scale. There was a cloudy sky, a rapidly falling barometer, following a frosty night, and local indications fell in with the wider aspect of affairs, suggesting "rain before long."

The explosions on August 22, 1907, were as follows:

RAKI'S TABLE.

Time.	Guncotton.	Dynamite.	Gunpowder.	Weight of charge.	How made up.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	
(10) 3:30 p. m.	....	100	....	100	In 10-gallon oil drum.
(11) 3:40 p. m.	....	100	....	100	Do.
(12) 3:50 p. m.	50	150	....	200	Do.
(13) 6:00 p. m.	....	150	50	200	In case and keg.
DALGETY'S HILL, DUNTROON.					
(14) 3:30 p. m.	33	67	....	100	In 10-gallon oil drum.
(15) 3:39 p. m.	33	67	....	100	Do.
(16) 3:49 p. m.	33	67	....	100	Do.
ROUND HILL, TOTARA.					
(17) 3:30 p. m.	25	25	....	50	In guncotton case.
(18) 3:40 p. m.	25	25	....	50	Do.
(19) 3:50 p. m.	25	25	....	50	Do.
(20) 3:55 p. m.	25	25	....	50	Do.

The charges were primed with dry guncotton and fired by dynamite detonator attached to a slow-burning fuse. In nearly all cases complete detonation took place, but it would have been much more satisfactory had each case of explosives been connected and the explosions made by electric current. In one instance it was noticed that three cases of dynamite exploded, one upward and two others sideways, and not quite simultaneously, so that it appeared as if a single cap was not sufficient for complete detonation. However, we thus had both effects—explosions ballistic in character and detonations shattering.

From Raki's Table I watched the experiments at Dalgety's Hill, 5¼ miles to the northeast, and those at Round Hill, 9½ miles to the southeast. The skies were again very heavy—stratus clouds,were between 800 or 1,000 feet above the Table most of the time, and hung low, but well defined underneath all round, excepting in one bright patch away to the southwest, where there was an arch over a mountain range. The wind at first was light northwest, and later shifted to the southwest without much change in the clouds, except perhaps they lowered as the evening advanced. This time, so far as I could see in any direction, there was no apparent change made by the explosions. The smoke drifted upward and then gently away on the breeze. The barometer fell slowly all the time and the high relative humidity approached saturation at sundown; but though the mist looked heavy all about, the rain was not quite ready and explosions did not seem to expedite matters. Up to that time the experiments certainly were ineffective in the precipitation of rain. It did, however, come some hours afterward, and some people in the locality might possibly attribute this result to the experiments, but those who were actual eye-witnesses on those lonely heights could, I imagine, hardly entertain such ideas. These efforts were puny in comparison with the mighty forces which were at that moment developing independently over thousands of square miles in a cyclone similar to, but more intense than, the one which had brought rain only a few days before. It did seem indeed to be following in its tracks.

Rain commenced at Oamaru about midnight with a northeast wind, and was general thruout the district of North Otago. Tho Central Otago did not benefit as much as expected, yet so far as the Oamaru district was concerned, the dry period was at an end and there was great rejoicing everywhere.

The rainfalls of the locality are placed, as usual, to the credit of the day preceding the morning on which they are read, and are as follows:

Aug.	Windsor Park.	Otekaike.	Livingstone.	Arnmore.	Kurow.	Waimate.	Oamaru.	Totara.	Kauroo Hill.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
22d ...	.47	.19	.41	.35	.23	.43	.39	.30	.31
23d ...	1.44	.88	1.12	1.65	.44	2.10	2.02	2.24	1.88

GENERAL OBSERVATIONS.

Besides the valuable statistical information acquired by me in Oamaru, an increased interest in meteorology itself has, I trust, been a direct outcome of these experiments in the district. Tho science may not yet be able to forecast drought periods, yet they may be promptly recognized, and then with the aid of experience to be gained from other lands, they may be combatted on scientific lines, thus by turning adverse circumstances to good account, success may be wrested even from apparent failure. These costly efforts at rain-making are regarded at present, as misguided and vain by all scientific meteorologists, while to their chagrin really valuable work is often neglected for want of public interest. On this visit I have established four new third-class stations for the observation of rainfall in the Oamaru district, and I would earnestly recommend the establishment of one second-class station at Oamaru.

The whole matter in regard to rain-making experiments resolves itself into the question—Can man according to the dictates of his own needs, either directly or indirectly, produce rain upon the earth? Professional rain-makers in civilized countries have made repeated efforts by various methods to cause rain, but from America, Europe, India, and Australia come records of their failure, and only personal experience seems to satisfy each nation and each generation of their futility.

The chief arguments used in favor of the experiments, besides those alluded to before, were that rain generally followed great battles, explosions, and disturbances of the air as by reverberations of thunder—nay, even the passage of a railway train thru a moist-ladened atmosphere. I was informed that in parts of Wales, where slate quarrying is carried on, it usually rains every day while blasting is done, but that the Sundays will be fine because operations cease. Reviews of troops and sham fights have been followed by rain, and this has been attributed to the firing. The coincidence of rain with reviews has often been unduly imprest upon the minds of people by its effect on smart dresses and uniforms, for the display of which, and for convenience in marching, cumbersome overcoats have been discarded, and this fact discounts such evidence. Prof. T. Russell, in his "Meteorology," says:

> It has been supposed that concussion of artillery fire in battles produces rain, and that great battles are followed by heavy rain. There is no reason why this should be so. No physical relation has ever been traced between concussion of air and formation of water-drops. The belief is very ancient that battles are followed by rain. In Plutarch's Lives it is related that after the battle of Marsalia, in France, a great rainfall followed, and it is mentioned as being a well-known fact that all great battles are followed by rain. This was certainly a case when rain was not due to artillery fire.

Globules of water are formed around particles of dust and the vapor atoms of gases, or ions, but there is no reason to suppose that these droplets are hollow vesicles which could be burst by explosions. Condensation is induced in a supersaturated atmosphere by the presence of dust, the fumes of ammonia, phosphorus, sulfur, etc., since these particles form nuclei for the minute spherical drops of water. The passage of a train might bring such [dust] in smoke, but the results would only be insignificant. Fog from smoke may rest over London, but the rain is no greater than in the country. Again, thunder and lightning are effects of electrical disturbance, which latter is also a result of the usual cause of precipitation, viz, a cooling of a vapor-ladened atmosphere. A thunderstorm is caused by the meeting of winds from different sources, one warm and moist and the other dry and cold. These may meet laterally, or there may be an overturning of the atmosphere when they suddenly meet above. The latter idea is theoretically the nearest approach to what is sought by advocates of explosions as a means of causing rain to fall. The sudden conversion of a solid explosive substance into gases perhaps 1,500 times greater in volume, is accompanied by force and heat, and tremendous expansion. This drives the air about in every direction and, until diffusion of the gases took place, would create a state of atmospheric instability. Condensation first takes place aloft, then possibly drops fall, introducing a cooler current which might cause local showers, such as fall from the cumulus or anvil-shaped thunderstorm clouds caused by "unstable equilibrium." For such effects I watched most carefully, but the explosions had apparently no more effect in this direction on the vast expanse of the air than would the striking of a match in a room.

The natural forces arrayed against artificial changes in the atmosphere are tremendous—almost beyond conception. A unit of heat is the amount needed to raise the temperature of a pound of water 1° F., but nearly a thousand such units are needed to transform a pound of vapor. When vapor returns to water, latent heat is liberated in a corresponding amount. Now an inch of rain corresponds to 21,635 gallons, or 100 tons, 3 quarters, 26 pounds of water to the acre, or over 64,640 tons to the square mile. The heat developed or released by the condensation from vapor to water for an inch of rain to the square mile is estimated as equivalent to the work done by 100,000,000 horse-power for half an hour. Consider then the sweep of a wind, five hundred miles wide and three miles high, blowing for an hour at the rate of twenty miles. The force of the mightiest explosion with all its gas put forth into the air is, in comparison, less than a drop in a bucket.

First and last, rainfall is always concerned with temperature in its relation to the aqueous vapor. Air at different temperatures will hold different quantities of water-vapor which is an invisible gas and lighter than the air itself. For example, at 80° F. two cubic feet of air will sustain 22 grains weight of vapor; at 60° F. the same measure would hold $11\frac{1}{2}$, but at 32° only $4\frac{1}{2}$ grains. Any additional moisture would be condensed at those temperatures, or a lowering of the temperature of the saturated air would have the same effect, namely, condensation. At ordinary temperatures the capacity of the air for vapor is doubled for every 18° F. Cooling the air by mixture of a cold upper current with a lower warm and vapor-ladened one, or the meeting of tropical and polar winds in circulating storms, or the impinging of a warm and moist air on a cold surface would condense the vapor into dew, fog, rain or snow; on the contrary a warm surface would evaporate water by the conduction of the heat from it to the water. Until it can be shown that the temperature of the air can be controlled by gigantic cooling operations we may look in vain for any alteration in the natural and well established order of events by way of the production of artificial rain.

In ancient times and long before European settlement, trees seem to have flourished in the Oamaru district, for I am told that big roots are still found in the soil, but, except around the old homesteads, the country is now bare of trees. Around their homes the settlers have mostly planted pines which have flourished wonderfully, but if larger and more varied plantations were made, particularly in belts intercepting the northwest and southwest winds, though they might not increase the rainfall yet the trees would act as shelters and windbreaks, and would also conserve the rainfall which now runs off in floods or evaporates in hot, dry weather. Where possible, the planting of deep-rooted rather than surface-rooting trees of a deciduous kind would bring up water from the lower water-tables and not only prevent surface evaporation by the winds, but also, as they transpire freely in the summer, create a beneficial humidity in their neighborhood. The excessive heat of a bare, sun-baked soil drives away the rain from a drought-stricken district and thus diminishes the "probability of rain" which otherwise could, from time to time, be reasonably expected. So far as one can see the only objections which can be urged against the planting of trees are the occupation of fertile lands by comparatively unproductive trees and the possible harboring of the small-bird pest. The losses, however, would undoubtedly be more than compensated for by wider general benefits, and the whole question is one of reforestation, which assuredly concerns the community at large, and could with advantage be dealt with by local or general government regulations.

Action with regard to both the planting and destruction of the trees is a matter of vital importance to the country. Whether forest trees increase the rainfall or are themselves the result of an abundant precipitation is not a question I would raise at the present time, but rather considerations of evaporation, shelter, run-off, etc., as affected by tree-planting, and are of more than passing interest to the people of Oamaru.

In conclusion I would like to remark that tho our seasons are usually so temperate, regular, and fruitful, yet climatic variations are of the greatest concern to the country.

SCHOOLBOYS' WEATHER OBSERVATIONS.

An interesting method of instructing boys in that part of nature study pertaining to the atmosphere has been devised by John Reid, the headmaster of the Reckleford Council School at Yeovil. Each day of the school week several boys are sent to the corporation gas works to copy the records of barometer movements and rainfall there kept, one or two less experienced lads accompanying them. Meantime other boys note the direction of the wind and record the temperature from readings of thermometers hung in the open on the north and south sides of the school. The teacher of the class then enters the particulars on a sheet, and encourages the scholars to make deductions from the collected data. The boys copy the results, and every Friday they write an account of their observations in the form of "general remarks" on the week's weather.—*London Standard.*

The practise of requiring scholars, boys and girls, in the lower school grades to observe, record, and discuss meteorological phenomena was introduced by the Editor into the Normal School at Washington, D. C., in 1882, and has since been tried with great success in all portions of the United States—being heartily supported as an important branch of "Nature Study." The weather maps and forecasts bring the importance of this subject home to the whole community. The above extract from a London paper shows that our science is also being emphasized in the English Public Schools.—*C. A.*

INTERNATIONAL EXCHANGE SERVICE.

Owing to some recent irregularities in the transmission of publications it has occurred to the Editor that possibly many foreign subscribers, exchanges, and recipients of the MONTHLY WEATHER REVIEW are not fully apprised of the workings of the service established by nearly all national governments as an outgrowth and development of the original Smithsonian system. We, therefore, reproduce a circular letter issued by that Institution on behalf of the U. S. International Exchange Service. Any further details desired can be had by addressing the Secretary of the Smithsonian Institution.

In effecting the distribution of its first publications abroad, the Smithsonian Institution established relations with certain foreign scientific societies and libraries, by means of which it was enabled to assist materially institutions and individuals of this country in the transmission of their publications abroad, and also foreign societies and individuals in distributing their publications in the United States.

In recent years the Smithsonian Institution has been recognized by the United States Government as in charge of its official Exchange Bureau, through which the publications authorized by Congress are exchanged for those of other governments; and by a formal treaty it acts as intermediary between the learned bodies and literary and scientific societies of the contracting states for the reception and transmission of their publications.

Attention is called to the fact that this is not a domestic, but an international exchange service, and is used to facilitate exchanges, not within the United States, but between the United States and other countries only. As exchanges from domestic sources for addresses in Hawaii, the Philippine Islands, Porto Rico, Guam, The Canal Zone, and other territory subject to the jurisdiction of the United States do not come within the designation "international," they are not accepted for transmission.

Packages prepared in accordance with the rules enumerated below will be received by the Smithsonian Institution from persons or institutions of learning in the United States and forwarded to their destinations through its own agents, or through the various exchange bureaus in other countries. The Smithsonian agents and these bureaus will likewise receive from correspondents in their countries such publications for addresses in the United States and territories subject to its jurisdiction as may be delivered to them under rules similar to those prescribed herein, and will forward them to Washington, after which the Institution will undertake their distribution.

On the receipt of a consignment from a domestic source it is assigned an "Invoice Number," this number being placed on each package contained in the consignment. A record is then made of the entire list of packages under the sender's name, and the separate packages are entered under the name of the person or office addressed. An account is thus established with every correspondent of the Institution, which shows readily what packages each one has sent or received through the Exchange Service. The books are then packed in boxes with contributions from other senders for the same country, and are forwarded by fast freight to the bureau or agency abroad which has undertaken to distribute exchanges in that country. To Great Britain and Germany, where paid agencies of the Institution are maintained, shipments are made weekly; to all other countries transmissions are made at intervals not exceeding one month.